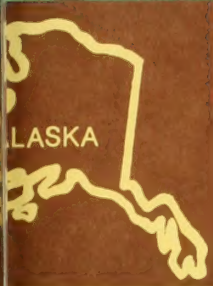


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OCCURRENCE AND GROWTH OF FOUR NORTHWESTERN TREE SPECIES OVER SHALLOW WATER TABLES

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ABSTRACT

The occurrence and radial growth of native red alder, western redcedar, Sitka spruce, and western hemlock trees were related to water-table depths from estimates made in skunk-cabbage swamps and stream bottoms on the Olympic Peninsula, Washington. All four species tolerated winter water tables more than 15 centimeters below the soil surface. Red alder and western redcedar also grew well where stagnant water was less than 15 centimeters deep, as did alder and Sitka spruce where the water was flowing. Western hemlock seemed intolerant of water tables less than 15 centimeters deep.

Keywords: Water-table, forest management, western hemlock, red alder, western redcedar, Sitka spruce, Douglas-fir.

INTRODUCTION

Shallow water tables underlie only a small fraction of the Pacific Northwest, but their importance is greater than indicated by the area involved. As recreational use of northwestern lakes and rivers increases, the lowland forests along their edges become increasingly valuable. Many of these forests grow over shallow water tables. As dams are built throughout the region, the resulting reservoirs create more shallow water-table areas. Unfortunately, not all of these newly created lowlands remain forested--upland trees often die when a reservoir creates a new shallow water table. The resulting snag patches are ugly, unproductive, and often avoidable. Several northwestern tree species tolerate shallow water tables. If these tolerant species are properly matched with water-table conditions, attractive and productive forests often can be reestablished.

Quantitative information relating the occurrence and growth of northwestern tree species to water-table depths is scarce. An earlier study of seedling growth over artificial water tables showed that lodgepole pine (*Pinus contorta* Dougl.), western redcedar, (*Thuja plicata* Donn), red alder (*Alnus rubra* Bong.), and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) seedlings grew moderately well over shallow water tables, but Douglas-fir barely survived.^{1/} However, the growth and survival characteristics shown by seedlings may not be maintained throughout the life of a tree, and artificial water tables may be different from water tables in the field. In the present study, we measured larger trees in the field to compare the occurrence and growth of red alder, western redcedar, Sitka spruce, and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.).

METHODS

In another study,^{2/} depths of winter water tables were found to be correlated with the density and petiole length of yellow skunk-cabbage and the presence or absence of slough sedge (*Carex obnupta* Bail.). These plants were used in the present study to estimate water-table depth. Fifty-six water-table

^{1/} Don Minore. Seedling growth of eight northwestern tree species over three water tables. Portland, Oregon, Pacific Northwest Forest & Range Exp. Sta. USDA Forest Serv. Res. Note PNW-115, 8 p., illus., 1970.

^{2/} Don Minore. Yellow skunk-cabbage (*Lysichitum americanum* Hult & St. John)--an indicator of water-table depth. Ecology 50: 737-739, 1969.

plots were established on the Olympic Peninsula, Washington.^{3/} The plots were located wherever undisturbed native trees and skunk-cabbage were found growing together--without regard to forest type, stand size, or canopy density. Each plot consisted of a 6- to 15-meter line intercept^{4/} along the contour where there were no hummocks, root wads, or other minor topographic irregularities. (Intercepts shorter than 15 meters were used to estimate water-table depths where topographic irregularities prevented use of a 15-meter line.) Petiole lengths of yellow skunk-cabbage plants encountered on this intercept were measured, and the presence or absence of slough sedge was noted.

Presence of slough sedge indicated an above-surface water table in the winter. Where slough sedge was absent, water-table depths were estimated by measuring the petiole length of the longest leaf on each mature skunk-cabbage plant encountered along the line intercept. These petiole lengths were then used to calculate winter water-table depth estimates for each of the 56 plot locations.^{5/}

At each location, tree species present at the same elevation as the water-table plot were recorded regardless of tree size. Radial growth for the last 10 years was then measured on a breast-high increment core obtained from a single tree of each species. All growth measurements were obtained from nearby dominant or codominant trees within 5 meters of the water-table plot, at the same elevation. Whenever possible, trees of similar diameter were bored for each species present at a given location. Where the only trees present were overmature (decadent, with flat-topped or partially dead crowns) or too small for increment boring, radial growth was not measured.

General observations of species present on adjacent high ground, movement of ground water, and comparative vigor of species were recorded wherever applicable.

RESULTS

Estimated winter water tables at half of the 56 locations were more than 15 centimeters below the soil surface. Seventeen of the remaining water-table plots indicated water tables 5 to 15 centimeters below the surface; 11

^{3/} Permission to work on lands of the Quinault Indian Reservation, Simpson Timber Company, and Washington State Department of Natural Resources is gratefully acknowledged.

^{4/} R. H. Canfield. Application of the line interception method in sampling range vegetation. J. Forest. 39: 388-394, 1941.

^{5/} Water table depth (cm.) = 27.98 - 0.38X

where X =
$$\frac{\text{Sum of petiole lengths (cm.) on entire intercept}}{\text{Length of intercept (m.)}}$$

indicated water tables from 5 centimeters below the surface to above the surface. Although abundant Douglas-fir seed sources were present throughout the study area, only two Douglas-fir trees occurred on these 56 locations. Four other species were more adequately represented: red alder, western redcedar, Sitka spruce, and western hemlock (table 1). Their occurrence (presence of one or more trees of a given species at the same elevation as the line intercept) over various water tables is compared in figure 1 where species presence is shown without regard to vigor or growth. Although red alder and western redcedar were more frequently present than Sitka spruce and western hemlock over winter water tables less than 5 centimeters deep, occurrence of spruce and hemlock over more than 25 percent of these extremely shallow water tables indicates that all four species can survive in very wet areas. However, the western hemlocks had pale needles and were growing very slowly (less than 1 millimeter of radial growth per year).

Figure 2, showing only those trees growing 10 millimeters or more during 10 years, presents a better comparison of species. Red alder, western redcedar, and Sitka spruce are still relatively abundant over the shallowest water tables in figure 2, but western hemlock is absent. Healthy, well-growing hemlocks were not found where winter water tables were shallower than 5 centimeters.

When single radial growth measurements for each location were plotted over the estimated winter water-table depths for these locations (figs. 3, 4, 5, and 6), the influence of flowing ground water was immediately apparent. Radial growth of red alder and Sitka spruce was much greater over flowing water than over stagnant water where water tables were extremely shallow. Day^{6/} recorded similar observations of Sitka spruce in British Columbia.

Locations with stagnant water tables were used in correlating radial growth and water-table depth for each species. These correlations were not significant for red alder and western redcedar; a logarithmic transformation of radial growth was significantly correlated to water-table depth for Sitka spruce and western hemlock. Apparently, water-table-depth differences were not related to growth differences in alder and cedar. Growth of spruce and hemlock decreased where stagnant water tables were nearer the soil surface.

Western hemlock and western redcedar seldom occurred over shallow water tables that were flowing--even where adjacent stands provided abundant hemlock seed sources. Both species were more common over shallow water tables that were stagnant, but hemlock grew very poorly there while cedar grew taller than any other species present.

^{6/} W. R. Day. Sitka spruce in British Columbia, a study in forest relationships. Great Brit. Forest. Comm. Bull. 28, 110 p., illus., 1957.

Table 1.—Estimated water-table depth, waterflow, tree species present, and tree measurements at each location

Estimated water table depth (centimeters)	Water-flow	Tree species present ^{1/}	Diameters and 10-year radial growth ^{2/} of measured trees							
			Red alder		Western redcedar		Sitka spruce		Western hemlock	
			D.b.h.	Growth	D.b.h.	Growth	D.b.h.	Growth	D.b.h.	Growth
			Inches	Milli- meters	Inches	Milli- meters	Inches	Milli- meters	Inches	Milli- meters
Above surface	Stagnant	WRC, LPP	--	--	S	--	--	--	--	--
"	"	WRC, WH, LPP	--	--	4	12	--	--	5	4
"	"	WRC, SS, WH, LPP, WWP	--	--	S	--	S	--	S	--
"	"	WRC, WH	--	--	S	--	--	--	S	--
"	"	RA	S	--	--	--	--	--	--	--
0	"	RA, WRC	6	18	11	43	--	--	--	--
0	"	RA	7	10	--	--	--	--	--	--
1	"	RA, WRC	10	23	11	26	--	--	--	--
Above surface	Flowing	RA	7	60	--	--	--	--	--	--
"	"	RA, SS	10	45	--	--	18	50	--	--
2	"	RA, WRC, SS	4	43	6	14	6	48	--	--
7	Stagnant	WRC, WH	--	--	18	22	--	--	SU	--
8	"	WRC, SS, WH, DF	--	--	13	14	17	4	14	2
10	"	RA, WRC	11	10	10	19	--	--	--	--
11	"	RA, WRC, WH	9	13	24	39	--	--	13	3
11	"	WRC, SS, WH	--	--	15	16	27	12	26	10
12	"	RA, WRC, WH	7	10	6	3	--	--	6	3
12	"	WH	--	--	--	--	--	--	8	4
12	"	RA, WRC, SS, WH	10	11	11	13	10	6	15	6
13	"	RA	12	8	--	--	--	--	--	--
13	"	WRC, SS, WH	--	--	4	10	3	5	4	5
13	"	WRC, WH	--	--	11	14	--	--	9	4
14	"	WRC, SS, WH	--	--	9	10	10	14	8	5
15	"	RA, WRC, SS, WH	12	4	16	28	10	9	15	7
15	"	WRC, WH	--	--	6	7	--	--	6	9
11	Flowing	RA	15	58	--	--	--	--	--	--
12	"	RA, SS	10	54	--	--	8	34	--	--
13	"	RA, SS, WH	4	28	--	--	4	38	4	34
16	Stagnant	RA, WH	6	8	--	--	--	--	8	10
17	"	RA	10	10	--	--	--	--	--	--
17	"	WRC, SS, WH	--	--	17	19	19	8	12	3
17	"	WH	--	--	--	--	--	--	3	10
17	"	WRC, WH	--	--	5	9	--	--	5	5
17	"	WRC, WH	--	--	8	15	--	--	8	10
20	"	WH	--	--	--	--	--	--	8	20
21	"	WRC, SS, WH	--	--	17	6	18	14	SU	--
21	"	RA, WRC, SS	9	17	9	20	6	18	--	--
21	"	RA	10	20	--	--	--	--	--	--
22	"	RA, SS, WH	SU	--	--	--	27	24	18	28
22	"	RA, WRC, SS, WH	SU	--	28	33	33	22	22	18
22	"	WRC, SS, WH	--	--	25	26	22	30	22	10
23	"	WRC, LPP	--	--	4	9	--	--	--	--
24	"	WRC, WH, LPP	--	--	6	14	--	--	6	16
25	"	WRC, WH, LPP, WWP	--	--	4	5	--	--	4	4
25	"	RA, WRC, SS	14	10	OM	--	OM	--	--	--
25	"	WRC, SS, WH	--	--	7	21	9	24	7	10
26	"	WRC, WH, WWP	--	--	16	40	--	--	15	15
26	"	WRC, WH	--	--	OM	--	--	--	6	9
26	"	WRC, SS, WH, DF	--	--	20	7	16	15	21	22
27	"	RA	9	34	--	--	--	--	--	--
16	Flowing	RA	14	18	--	--	--	--	--	--
16	"	RA, WH	9	28	--	--	--	--	8	32
20	"	RA, WRC, SS, WH	S	--	S	--	S	--	S	--
21	"	RA, WRC	9	35	S	--	--	--	--	--
24	"	RA, WRC, SS	3	27	3	15	3	6	--	--
24	"	WH	--	--	--	--	--	--	17	27

^{1/} RA= red alder, WRC = western redcedar, SS = Sitka spruce, WH = western hemlock, LPP = lodgepole pine, WWP = western white pine, DF = Douglas-fir.

^{2/} Where diameters and radial growth measurements are absent, the trees were overmature (OM), suppressed (SU), or too small for increment boring (S).

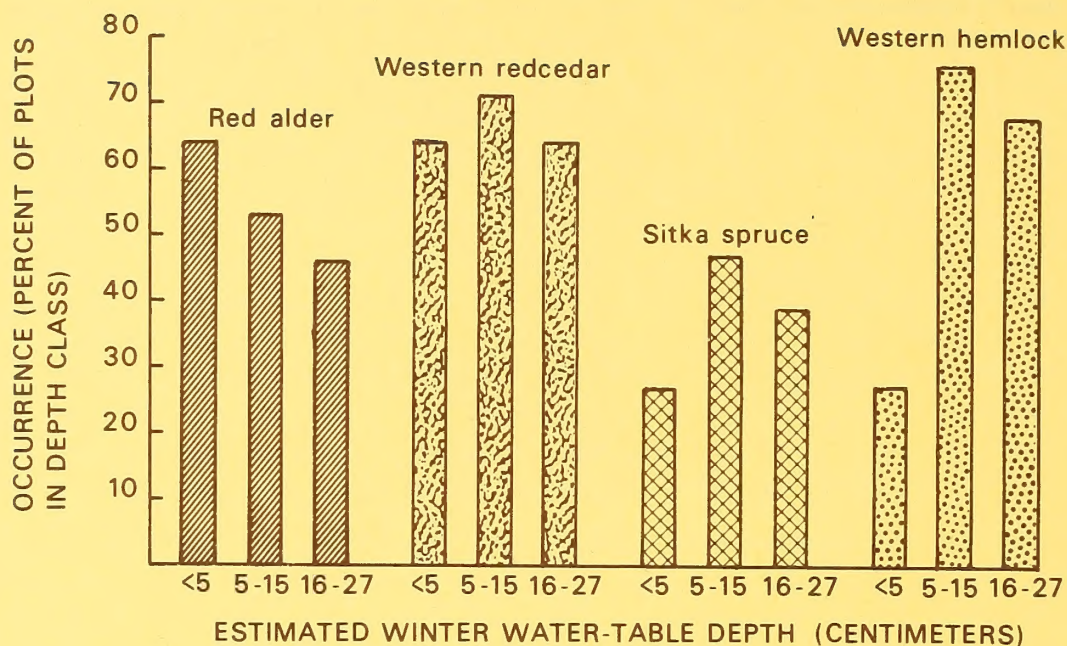


Figure 1.--Species occurrence over shallow water tables.

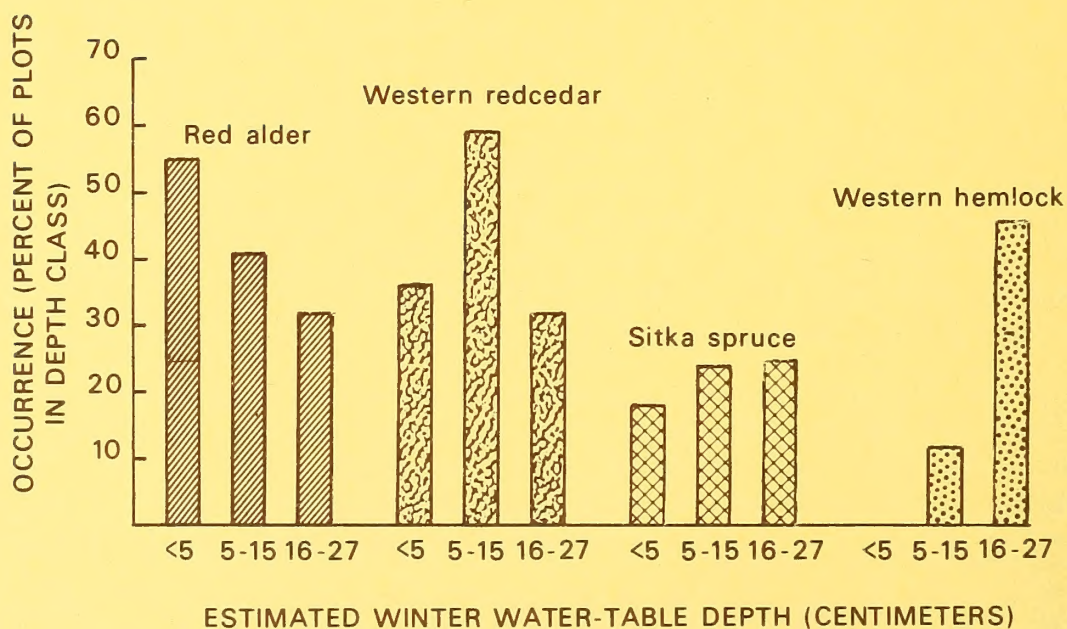


Figure 2.--Occurrence over shallow water tables of trees growing 10 millimeters or more in 10 years, by species.

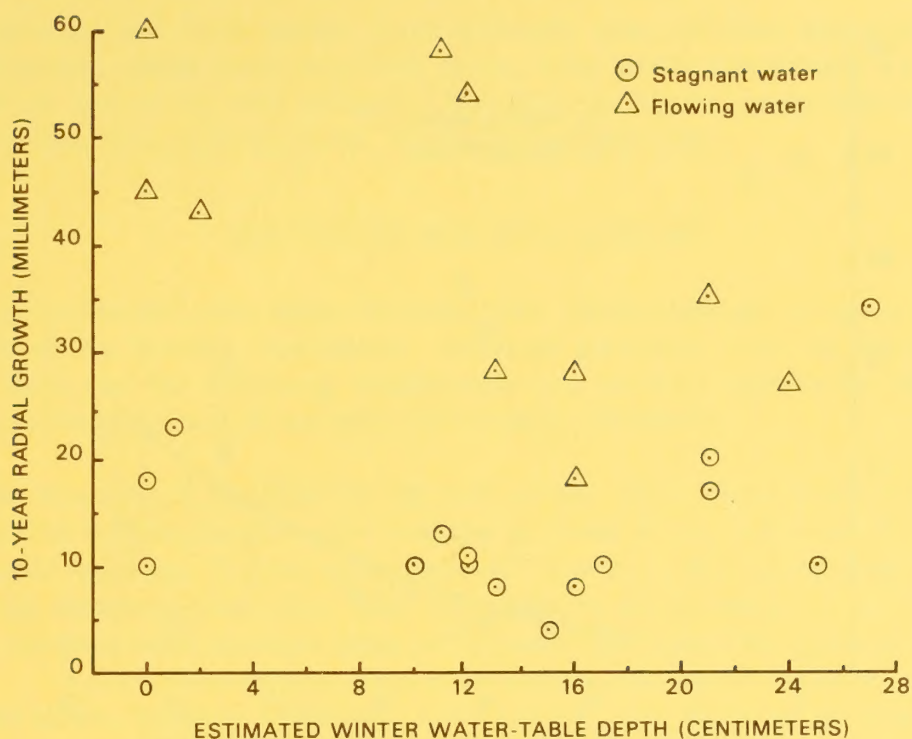


Figure 3.--Relation of radial growth of red alder to depth of winter water table.

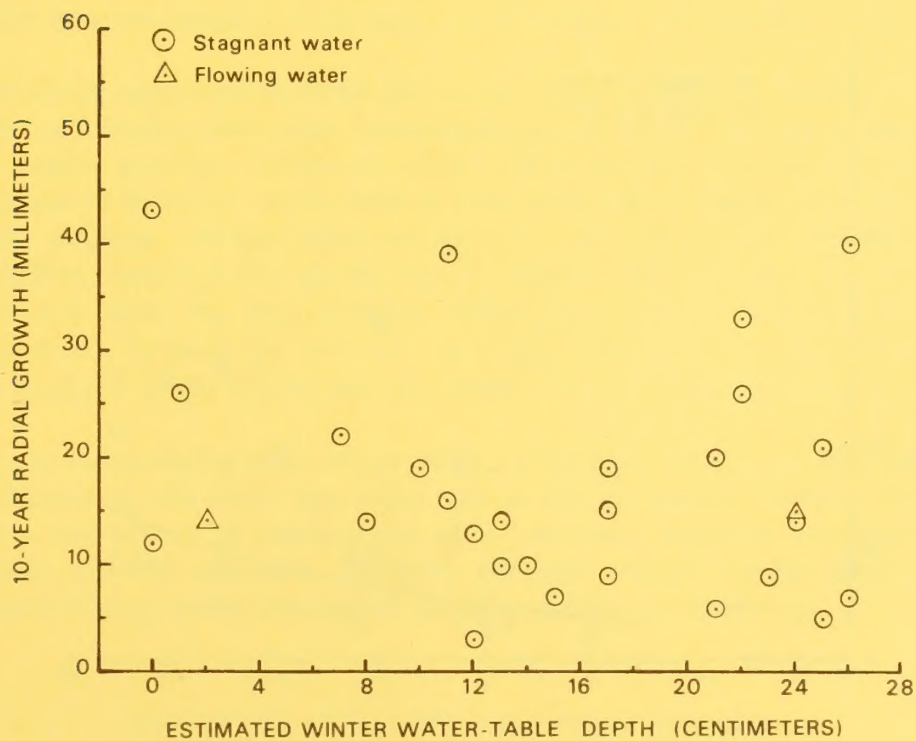


Figure 4.--Relation of radial growth of western redcedar to depth of winter water table.

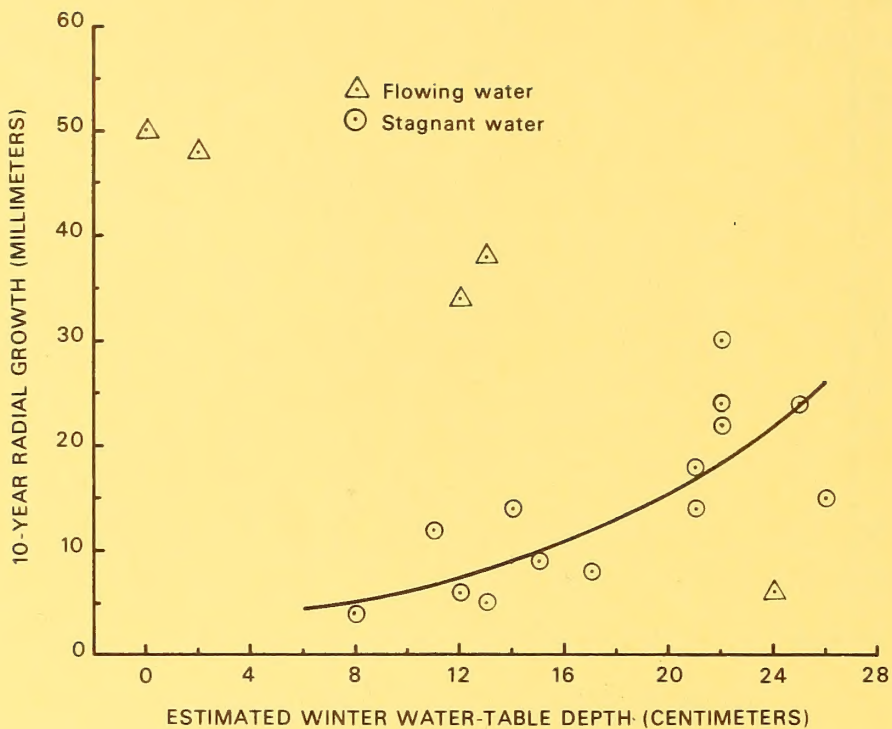


Figure 5.--Relation of radial growth of Sitka spruce to depth of winter water table.

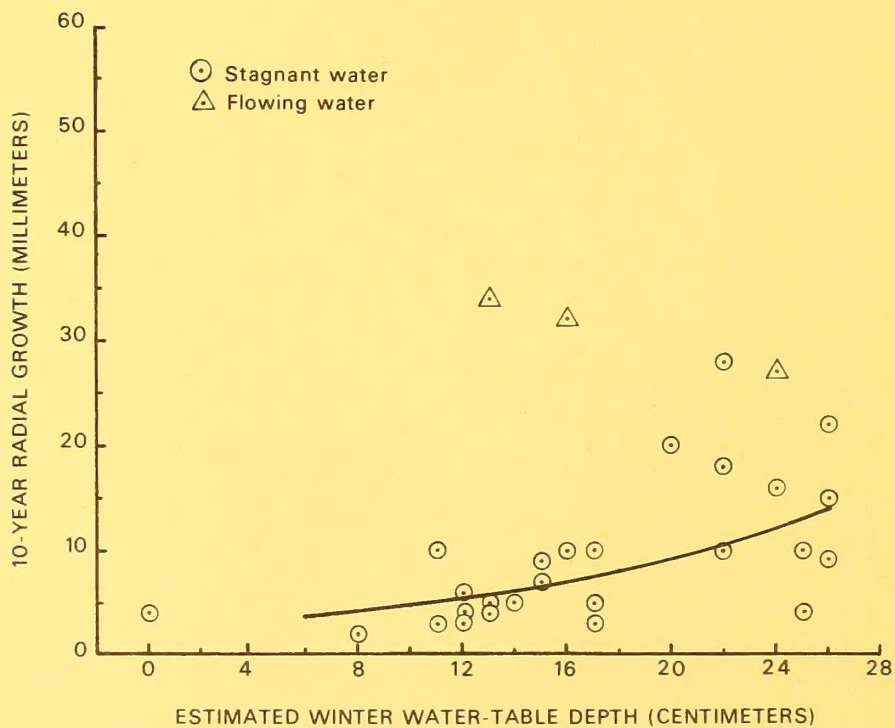


Figure 6.--Relation of radial growth of western hemlock to depth of winter water table.

Red alder and Sitka spruce were common over shallow water tables that were flowing. Both grew very well there, even where the winter water table was at or above the soil surface. Red alder was also common over shallow water tables that were stagnant. Sitka spruce was not.

DISCUSSION AND CONCLUSIONS

Data presented here were obtained from skunk-cabbage areas in one small portion of the Pacific Northwest. Although probably valid for other areas, these data and the following conclusions are strictly applicable only where skunk-cabbage occurs on or near the Olympic Peninsula.

The absence of Douglas-fir on wet areas, even where these areas were surrounded by Douglas-fir seed sources on drier sites, indicates that Douglas-fir cannot tolerate shallow water tables. However, the absence of lodgepole pine and western white pine does not indicate intolerance for shallow water tables because seed sources were not present for these two species.

Red alder, western redcedar, Sitka spruce, and western hemlock can all be considered adaptable to shallow water tables. All four seem able to tolerate winter water tables that are moderately shallow, and species differences are obscure where estimated winter water tables are more than 15 centimeters below the surface. Where water tables are less than 15 centimeters below the surface, the species respond differently to both depth and quality of the water table.

Red alder and western redcedar seem little affected by water-table depth, growing reasonably well even where stagnant water is near or at the surface during winter months. However, alder grows much faster where water near the surface is flowing. Sitka spruce also grows well where flowing water is near the surface. Spruce does not seem to tolerate stagnant water tables that are shallow, and it grows slowly where stagnant winter water is less than 15 centimeters from the soil surface. Western hemlock seldom occurs where flowing water is near the surface. It is quite common but grows very slowly where stagnant water tables are shallower than 15 centimeters.

Where estimated winter water tables of flowing water are shallower than 15 centimeters, red alder and Sitka spruce can be grown. Where the water is stagnant and within 15 centimeters of the surface, western redcedar or red alder are suitable species. Western hemlock should not be grown where estimated winter water tables are shallower than 15 centimeters.

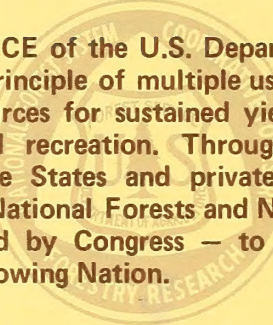
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